MODELING STUDY OF PCBs IN THE HOUSATONIC RIVER PEER REVIEW

Modeling Framework Design
Final Written Comments

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RESPONSE TO CHARGE FOR THE HYDRODYNAMIC MODELING PEER REVIEW

I. General Overview of Response

- The effort to assemble, modify as necessary, interface, then calibrate and validate three sophisticated models to an acceptable level of accuracy, could be very time consuming, especially since the models have never been used together in such an application. Thus a major concern is whether acceptable results can be obtained in a reasonable time. Given the time that will be required to complete the upstream (0.5 and 1.5 mile) remediation activities, perhaps the modelers could be given more time to develop the model(s) which will be used for potential remediation in the PSA.

- The task is made harder by constraints imposed by the consent decree and the fact that there are two modeling teams (EPA and GE) working essentially independently. If the peer review panel could interact more directly with the modeling team(s) and with their consultants, the task would be easier. It seems strange to think that GE will be handed the EPA model suite and then asked to use it. So much of modeling has to do with the "feel" for the model. I would find this quite awkward. Wouldn't it be easier for them to participate more directly in the model development?

- The model framework, as presented, seems too complicated. I would prefer if the developers started with a conceptual model, then progressed to more sophisticated models as needed. The conceptual model could nominally include all of the potentially important processes, but just not with complete spatial and temporal resolution. This way it would be easier to see which processes were really important and which could be eliminated or approximated more simply. There is a nice discussion of conceptual modeling, at the beginning of Chapter 3 of the MFD, but it appears that the modelers are starting big and planning to pare down. Perhaps they will end up at the same place.

- Regardless of whether ones builds up or pares down, each iteration requires some model-data comparison (hence, calibration) to assess model adequacy. As such, it may be difficult for the peer review process to conform strictly to the prescribed sequence of model framework design, calibration, then validation.

- Perhaps most importantly, the model framework needs to consider the particular application, and the sensitivity of model processes/parameters to that application. This point is made in the statement of model objectives, but it seems to be lost in the detailed framework design. My sense is that it is easier for a model(s) to reliably compare the environmental benefits of various mitigation options, than it is to predict absolute contaminant concentrations a decade into the future. That is, model predictions of relative benefits may be less sensitive to some highly uncertain processes/parameters because these processes/parameters are common to several applications and hence errors in the

way they are represented may cancel. By looking at applications from the beginning, a lot of extra work may potentially be avoided.

- The process of model development involves sensitivity. The charge to the peer review panel asks whether or not this or that process/parameter is "adequate". The answer, in part, depends on model sensitivity (in the context of the proposed applications). We won't be able to fully answer these questions until we see more model-data comparisons.

- Everyone has their own guidelines for developing/evaluating models, but one I like was generating by an ASCE task committee I served on some years ago. The paper which was generated by that committee (Ditmars, et al., 1987[1]) includes six steps in model performance evaluation which might be helpful to the modeling team. These steps include:

    1. Identification of problem
    2. Relationship of model to problem
    3. Solution scheme examination
    4. Model response studies
    5. Model calibration
    6. Validation studies

- Despite these somewhat negative general comments, there is a lot of strength behind this project. The suite of chosen models is quite sophisticated and each model has been successfully applied in a number of previous cases (though unfortunately none quite like the present). Furthermore, the modeling team and their consultants appear experienced, they have diligently addressed a broad array of questions, and they have assembled and/or are planning to collect a lot of field data.

- As such, I remain cautiously optimistic and look forward to viewing model results.

[1] Ditmars, J. D., E. E. Adams, K. W. Bedford and Dennis E. Ford, 1987, "Performance evaluation of surface water transport and dispersion models", J. Hydraulic Engineering, 113(8):961-980.

II. Response to Peer Review Questions

In considering the foregoing general issues and evaluating the EPA documents, the Peer Review Panel shall give specific consideration to the following questions. As modeling activities proceed, additional specific questions may be identified the panel to address.

A. Modeling Framework and Data Needs

1. ***Do the modeling frameworks used by EPA include the significant processes affecting PCB fate, transport, and bioaccumulation in the Housatonic River; and are the descriptions of these processes in the modeling framework(s) sufficiently accurate to represent the hydrodynamics, sediment transport, PCB fate and transport, and PCB bioaccumulation in the Housatonic River?***

- Many of the PCBs are in floodplain areas on the fringe of the various sub-watersheds. It is not clear to me whether these PCBs are more likely to enter the river by erosion from an occasional flood, a process handled by EFDC, or by wash-off from more frequent rainfall and snow melt, processes originally assigned to HSPF, but now apparently to be neglected.

- I would like to see more information on the mass exchange coefficients (or functions) describing sediment-water exchange

- I would like to see more information on near-bottom sediment conditions; e.g., the role that any bottom fluff layer may play in sediment-water exchange.

- Several papers have been written describing the extent of possible in situ remediation, either natural or engineered. It is not clear how this is to be modeled.

2. Based upon the technical judgment of the Peer Review Panel:

a. ***Are the modeling approaches suitable for representing the relevant external force functions (e.g.. hydraulic flows, solids and PCB loads, initial sediment conditions, etc.), describing quantitative relationships among those functions, and developing quantitative relationships between those functions and PCB concentrations in environmental media (e.g., water column, sediments, fish and other biota, etc.)?***

Watershed/HSPF:

- HSPF certainly appears adequate for modeling routine flow and TSS.

- I originally had questions regarding the ability of HSPF to model PCB wash off. This is because HSPF is a lumped parameter model not well-suited to simulating wash-off of contaminants concentrated in a relatively narrow (fringe) area of each sub-watershed. Now, however, that has been removed from the scope (though it is not clear that the process is not important).

- As noted in the response to my question 11 (Question 113), spatially resolved models such as MIKE-SHE do exist, and could be used to compute PCB runoff from the fringe areas of the watershed. I have not used this particular model, and am not advocating it, per se, but hydrologists in our department are using it on comparable types of applications.

River/EFDC:

- For typical flows (within banks) modeling is relatively simple, since there is no communication between banks and floodplains. One could go with either curvilinear coordinates or Cartesian. My hunch is that curvilinear is better, but perhaps Cartesian is safer. (Here it would be nice to be able to sit down with QEA and John Hamrick to more fully discuss advantages, disadvantages, pitfalls, etc.) In either case, the resolution can be quite small (order of 5 elements per width), momentum and mass should be conserved and the model should be sufficiently efficient so that multiple runs can be made.

- EFDC is a generalized 3-D hydrodynamic/transport code, and not a river model *per se*. Along with some of the other panel members, I am concerned about the lack of previous applications to predict erosion and transport in complex channels and the possible need to engage in code enhancements in the middle of a tight schedule. This sounds like interesting research that might not bear fruit in a timely fashion.

- In view of this uncertainty, other simpler models should be explored. GSTARS was mentioned.

- Several PCB congeners or homologs, spanning a range of appropriate partition coefficients, should be included in the EFDC simulations. As emphasized during the review meeting, the degree of hydrophobicity could substantially affect chemical residence time.

- Initial bathymetry (1980) will be developed using current bathymetry and subtracting sediment deposition inferred from Be-7, Pb-210, Cs-137, etc. Then when the model is run forward, the same deposited sediments will be added, presumably yielding current conditions. While this should

provide a good history of recent morphology, it is not predictive of future changes. It is unfortunate that there are not any independent estimates of historical bathymetry.

Bioaccumulation/AQUATOX:

- I am not very familiar with AQUATOX, but based on the panel discussion and Park et al. (1999), the model may be more complicated than necessary. AQUATOX includes ecosystem modeling that doesn't seem necessary, when only bioaccumulation is required. Indeed, if one assumes that the ecosystem won't change, the relative impact of various mitigation options should simply depend on the relative water column and sediment concentrations.

Interfacing:

- HSPF includes a relatively simple river model. As long as EFDC is going to be used to transport PCBs in the river, it is not clear why it is necessary to develop/calibrate the river section of HSPF. Conversely, as a first cut, it seems possible that the river section of HSPF could be augmented to handle the transport tasks asked of EFDC.

b. ***Are the models adequate for describing the interactions between the floodplains and the river?***

- The proposed coupling between river and floodplain is complicated and does not conserve momentum.

- It seems like the river is the more important part. This is where most organism exposure takes place and is the only region that AQUATOX simulates. The floodplain is not involved during normal flows and during high flow serves principally as a sink. The high flow erodes the channel bottom and banks, depositing sediment and PCBs on the floodplain (like a snow blower).

c. ***Are the models adequate for describing the impacts of rare flood events?***

- Rare flood events are difficult to simulate, because they require coupling between the floodplains and the river. It is not clear that the proposed approach will work. But I am not sure it is that important to fully simulate rare events. Based on data presented at the review meeting, during high flow, flow rate and concentration may each be about ten times higher than under average conditions, making water column transport about 100 times higher. And if high flows occur about one percent of the time, then the time-averaged water column mass transport under high and average conditions are about equal. But our concern is with bioaccumulation, which is proportional to time-integrated concentration (both sediment and water column) and not transport. The contribution of extreme

events would be only 10 percent for water column and 1 percent for sediment (assuming no change in sediment concentration). Hence bioaccumulation should result much more from exposure at average, rather than extreme, flows.

- Floods erode channel bottoms and banks resulting in particle-sorbed PCBs being transported downstream and sequestered in Woods Pond. Dissolved-phase PCBs liberated during this process will simply be washed downstream. Hence high flows are helpful for removing PCBs from the basin and errors in their representation are thus conservative. Since we are not able to predict extreme events in other than a statistical sense, anyway, I would think their role could be simulated with simple erosion/deposition assumptions, rather than a complex coupling of models with nested grids, etc.

d. ***Are the models adequate for discriminating between water-related and sediment-related sources of PCBs to fish and other biota?***

3.Again, based upon the technical judgment of the Panel, are the spatial and temporal scales of the modeling approaches adequate to address the principal need for the model - producing sufficiently accurate predictions of the time to attain particular PCB concentrations in environmental media under various scenarios (including natural recovery and different potential active remedial options) to support remedial decision-making in the context described above in the Background section? If not, what levels of spatial and temporal resolutions are required to meet this need?

- I would like to see the model domain extended further upstream. I realize, as the modeling team reiterated in their response to my question 4 (Question 106), that the present focus is the region between the confluence and Woods Pond. However, the ongoing/proposed remediation in the upper two miles above the PSA would provide a good basis for model/data comparison. Can the models predict the (presumably substantial) decrease in PCB loading arriving at the confluence following remediation? This will likely be a much bigger perturbation (hence more valuable test of model skill) than the changes that have occurred in the approximately 20 year period used for calibration/validation. It would also parallel one of the potential mitigation options that could be chosen for the PSA.

- Similarly, while the generally lower PCB concentrations downstream of Woods Pond imply that this region is less important from a human and ecological health standpoint, valuable data have been collected, and it would be nice to see if the model can predict them. Demonstrated skill in properly predicting these downstream concentrations can be used to assert confidence in model predictions upstream of Woods Pond, including conditions after mitigation when PCBs loadings in that region will also be smaller.

- From my experience, the issue of rainfall disaggregation (as input to HSPF) is critical, but the modelers recognize this, and have identified procedures for combining local data collected at daily intervals with more distant hourly data. Hopefully their procedures will be validated by measurements of short-term river flow and TSS data.

- AQUATOX will be run with a daily time step. The response to my question 23 (Question 125) clarifies that the computational time step can be subdivided (based on an adaptive time-stepping algorithm), but the loads will be aggregated. Since storms are important for transport, it is not clear if daily aggregation will be adequate.

4. Is the level of theoretical rigor of the equations used to describe the various processes affecting PCB fate and transport, such as settling, resuspension, volatilization, biological activity, partitioning, etc., adequate, in your professional judgment, to address the principal need for the model (as defined above)? If not, what processes and what resolution are required?

5. What supporting data are required for the calibration/validation of the model on the spatial and temporal scales necessary to address the principal need for the model (as defined above)? What supporting data are required to achieve the necessary level of process resolution in the model?

- Combine answer with 6.

6. Based upon your technical judgment, are the available data, together with the data proposed to be obtained by EPA, adequate for the development of a model that would meet the above referenced purposes? If not, what additional data should be obtained for these purposes?

- One objective of the study is to assess natural recovery. The two-year calibration period is useful to assess model skill in simulating processes, but too short to see much natural recovery, as the team concedes in their answer to my question 3 (Question 105) I wonder if a larger portion of the 20-year study period should be devoted to calibration rather than validation, or if additional data (GE or earlier EPA) should be used?

- It is unfortunate that there are not good data available for establishing initial bathymetry. The plan to use bathymetry and subtract sediment deposition inferred from Be-7, Pb-210, Cs-137 seems reasonable under the circumstances, but it is not predictive.

- Bioturbation is mentioned in several places, but I have not found reference to calculated bio-mixing coefficients.

- The current data collection program should be extended through the terms of the upstream remediation (0.5 and 1.5 mile) activities.

III. Specific Comments on the Modeling Framework Design Report and/or the Quality Assurance Project Plan.

IV. Concluding Comments